CHAPTER

12 Interest and Its Development, Revisited

K. Ann Renninger *and* Stephanie Su

Abstract

This chapter focuses on interest as a cognitive and affective motivational variable that develops and can be supported to develop. It provides an explanation of Hidi and Renninger's (2006; Renninger & Hidi, 2016) four-phase model of interest development and its relation to other approaches to interest, including interest conceptualized as an emotion, experience, task features, value, or vocational interest, and considers issues pertaining to the identification and measurement of interest as a variable that develops. Following this, the chapter reviews research that tracks interest over time as well as studies that focus on earlier and/or later phases of interest, with particular attention to (a) the triggering of interest in both earlier and later phases of interest, (b) maintaining interest once it has been triggered, (c) fluctuations in interest, and (d) shifts between phases in the development of interest. Two studies of interest development are reviewed in depth and their complementarities are described to illustrate how consideration of study complementarity can provide validation and insight about interest development. Finally, a Punnett square is used to demonstrate how it can enable the identification of relations among a learner's phase of interest, the achievement demands of the learning environment, and metacognitive awareness, in addition to suggesting next steps for the study of interest development.

Keywords: achievement, affect, interest, interest development, knowledge, metacognition

Interest and Its Development, Revisited

Interest is powerful. Its presence has been repeatedly demonstrated to benefit learning—it promotes attention, goal setting, and strategy use, and it is also malleable.[1] Moreover, interest may be supported to develop at any age, whether a person is in or out of school. In this chapter, we review research that contributes to understanding interest as a cognitive and affective motivational variable that both develops and can be supported to develop. The chapter centers on aspects of development that are not yet well understood—the conditions that support the development and deepening of interest and their implications for both theory and practice. We begin with an analysis of an excerpt from Helen Keller's autobiography, *The Story of My Life* (Keller, 1903). Helen's case, as it is presented in her autobiography, can illustrate critical aspects in the development of interest, starting with the initial triggering of interest through to the point where she asks questions, reflects on them, and voluntarily and independently follows through to seek answers and feedback.

Helen Keller was the first blind person to receive a bachelor's degree. She became a world-famous activist, wrote books about her experience and beliefs, and is now widely considered one of the most

[1] This chapter is an updated and revised version of our 2012 chapter, written for the first edition of the *Oxford Handbook of Motivation*. We draw on and extend points discussed in Renninger and Hidi's (2016) volume, *The Power of Interest for Motivation and Engagement*. Whereas that volume provides detail about interest, its development, and implications for research and practice, here we focus on issues and open questions central to further clarifying present understanding of interest development.

inspirational people of the 20th century. Through the support of her tutor, Anne Sullivan, Helen "discovered" language, communication, and society. Helen's interest development is paraphrased briefly below:

> Rendered both deaf and blind at a young age, Helen stumbled around like a feral animal for many years. The adults around her were unable to reach or tame her, pitying her and letting her do anything she wanted. When Anne Sullivan, a young and financially strapped tutor, was hired to help Helen, she found a bright but horribly spoiled 7-year-old girl who was unable to see the implications of her own behavior and its effect on other people. Anne did not approve of the way that Helen grabbed food from various people's dinner plates and broke things during temper tantrums. Anne disciplined, and Helen fought back both physically and with pranks.
>
> Anne recognized that Helen was bright and decided to teach her how to finger spell, thinking that this might help her to communicate with others. Anne would put an object in one of Helen's hands, and in the other quickly spell the name for the object. Even though Helen could imitate well, she did not understand what Anne was trying to teach her. Her patience ran out quickly, and the lessons would end in tears and yelling.
>
> Everything changed one day when Anne pumped water into Helen's hands and spelled "water." The event appeared to trigger Helen to make a connection between the fluttering movement in her hand and the cold liquid spilling over her skin. Suddenly, Helen realized what Anne had been trying to show her as she had doggedly spelled word after word into her hand all those weeks. From then on, Anne could hardly keep up with Helen, who dragged her around demanding a word for everything she encountered, everything that had been there before.

Anne's efforts to help Helen make connections between signs and what they represent could be described as potential triggers for interest. We do not know why or how the trigger of the water served as a catalyst. In fact, Helen thought at first that it was some kind of game. It seems likely that many factors contributed to her revelation.

We know, however, that a few elements of Helen's story are particularly important to the description and understanding of interest development. First, the development of her interest involved seemingly repetitive and ineffective external support before she made a connection between the finger spelling and the water and then engaged the challenge of revisiting the prior lessons that had been so frustrating to her. She did not simply decide to be interested in communication. Rather, it seems that she needed to encounter the connection to communicate, and it was the connection that triggered her eventual interest in communication more generally.

Second, Helen was not aware that she was developing an interest as her tutor worked with her. The potential triggers of finger spelling did not "take" until the incident with the water. Even at that point, it is not clear that she would have described finger spelling, or communication more generally, as something in which she was personally invested and that would hold her interest. However, her knowledge and valuing of the possibility of communicating using finger spelling were increasing.

Third, Helen's interest developed in a context where her strengths and needs were accounted for and she was not being graded or assessed: Anne worked with her so that she would understand and be able to think and explore. Once her interest began to develop, Helen was extremely successful by any number of measures.

Fourth, Helen's interest continued to develop because, once she made the connection between finger spelling and communicating, she then wanted to seek information. This led her to continue to stretch her own understanding.

Fifth, once she began seeking information, Helen began to self-regulate and to explore and seize opportunities to learn—opportunities that were ostensibly present before, but that she may not have been able to recognize without external support.

It appears that it was not until Helen made a connection between finger spelling and communication that she began to pose her own questions, seek answers, and reflect—a point when her interest in communication was clearly developing. As Helen's case reveals, the development of interest has phases that precede what to the outside observer might be readily identified as *interest*. In fact, her interest continues to develop beyond the phase that is detailed here.

Defining Interest and Interest Development

Interest refers both to the psychological state of learners during their engagement with particular content (e.g., communication, mathematics, basketball) and to their motivation to continue to reengage that content over time. First, we summarize the

development of interest through four phases, as described in the four-phase model of interest development (see Table 12.1; Hidi & Renninger, 2006; see also Renninger & Hidi, 2016). To provide a context for understanding a developmental approach, we present an overview of other approaches to the study of interest. In later sections of this chapter, we review studies in which interest is examined over time as well as studies that have focused on earlier and/or later phases in the process of interest development, discuss validation and insight about interest development based on the complementarity of two studies, and describe issues central to next steps in understanding the development of interest.

The Four-Phase Model of Interest Development

The four-phase model of interest development (Hidi & Renninger, 2006; Renninger & Hidi, 2016) identifies four phases in the development of interest: triggered situational, maintained situational, emerging individual, and well-developed individual interest. As described in Table 12.1, the four phases of interest are sequential and discrete, but as Hidi and Renninger (2006) also noted, they are phases rather than stages because the length and character of a given phase may vary among individuals based on experience and temperament, among other factors. The first phase in the development of interest is conceptualized as being initiated by a triggered situational interest. If sustained, this first phase evolves into the second phase, maintained situational interest. The third phase of interest, emerging individual interest, may develop out of the second phase and may then lead to the fourth phase, a well-developed individual interest.

Helen's experience with finger signing provides an illustration of triggered and eventually maintained situational interest that evolved almost immediately into an emerging individual interest. Helen's interest was apparently triggered by the juxtaposition of the water and the finger signing, which represented the presence of a new concept: communication. Her interest for communicating using finger spelling was maintained following the triggering provided by the water, and although she first engaged in communication as a game, it began to take on meaning for her. It also led her to ask questions because she wanted to understand, marking a shift in her phase of interest. Based on what Helen tells us in her autobiography, she appears to have transitioned through the phase of maintained situational interest almost immediately, possibly because she had Anne to instantly respond and work with her to find answers to the curiosity questions she posed. As her autobiography also indicates, Helen continued to want to ask questions that allowed her to develop her knowledge. Her emerging individual interest rapidly developed into a well-developed individual interest.

The example of Helen demonstrates that once interest is triggered, it can be maintained and then progress as individual interest. Helen's interactions with others were critical; this is a characteristic of interest development that is now well established (e.g., Barron, 2006; Bergin, 2016; Nolen, 2007; Pasupathi & Rich, 2005; Thoman, Sansone, & Pasupathi, 2007). At first, these interactions could be characterized as supporting the generation of interest (e.g., Mitchell, 1993; Palmer, 2004, 2009). Later, they involved the provision of information that led her to continue to stretch, engage, and explore the content of her interest (see Renninger, 2010) or to self-generate interest (Sansone, Weir, Harpster, & Morgan, 1992; Sansone, Wiebe, & Morgan, 1999).

Studies of interest development can be focused on earlier (less developed) or later (more developed) phases of interest and named situational and individual interest, respectively. In such cases, situational interest is often used to describe the triggering of a response to particular content, activities, or events in the moment that may hold over time (Hidi & Baird, 1986; Mitchell, 1993), and individual interest as an increasingly consolidated base of discourse, or disciplinary, knowledge, and coordinated value for content (Renninger, 1990, 2000). However, as Renninger and Hidi (2016) explained, research now demonstrates that situational interest is triggered in both earlier and later phases of interest (e.g., Crouch, Wisittanawat, Cai, & Renninger, 2018; Durik & Harackiewicz, 2007). Situational interest may develop into individual interest, and situational interest may occur simultaneously with individual interest. In proposing the four-phase model, Hidi and Renninger (2006) suggested that findings from studies of situational and individual interest were complementary and could be used to map the development of interest, beginning with forms of initial triggering that might be sustained to the relatively enduring predisposition to return to particular classes of content over time. As they pointed out, interest development is propelled by the development of knowledge and coordinated valuing, which may be promoted through interactions with others, such as teachers, peers, parents, or museum personnel,

Table 12.1 The Four Phases of Interest Development (Hidi & Renninger, 2006): Definitions and Learner Characteristics

	Phases of interest development			
	Less developed (earlier)		More developed (later)	
	Phase I: Triggered situational interest	**Phase 2: Maintained situational interest**	**Phase 3: Emerging individual interest**	**Phase 4: Well-developed individual interest**
Definition	• Psychological state resulting from short-term changes in cognitive and affective processing associated with a particular class of content	• Psychological state that involves focused attention to a particular class of content that reoccurs and/or persists over time	• Psychological state *and* the beginning of relatively enduring predisposition to seek reengagement with a particular class of content over time	• Psychological state *and* a relatively enduring predisposition to reengage a particular class of content over time
Learner characteristics	• Attends to content, if only fleetingly • May or may not be reflectively aware of the experience • May need support to engage from others and through instructional design • May experience either positive or negative feelings • May not persevere when with confronted with difficulty • May simply want to be told what to do	• Reengages content that previously triggered attention • Is developing knowledge of content • Is developing a sense of the content's value • Is likely to be able to be supported by others to find connections to content based on existing skills, knowledge, and/or prior experience • Is likely to have positive feelings • May not persevere when with confronted with difficulty • May want to be told what to do	• Is likely to independently reengage content • Has both stored knowledge and stored value • Is reflective about the content • Is focused on his or her own questions • Has positive feelings • May not persevere when confronted with difficulty • May not want feedback from others	• Independently reengages content • Has both stored knowledge and value • Is reflective about the content • Is likely to recognize others' contributions to the discipline • Self-regulates easily to reframe questions and seek answers • Has positive feelings • Can persevere through frustration and challenge to meet goals • Appreciates and may actively seek feedback

From *The Power of Interest for Motivation and Engagement* by K. A. Renninger & S. E. Hidi, 2016, Table 1.2, p. 13. Copyright by Taylor and Francis, reprinted with permission.

and the tools that they have created (e.g., books, tasks, software, exhibits; Renninger & Hidi, 2016, 2019).

Empirical support for the four-phase model has been provided by studies conducted across a wide range of domains and contexts, with learners who vary in age (e.g., Harackiewicz, Durik, Barron, Linnenbrink, & Tauer, 2008; Lipstein & Renninger, 2007; Michaelis & Nathan, 2015; Wang & Adesope, 2016). Furthermore, developments in affective neuroscience indicate that the triggering of interest is associated with activation of the reward circuitry in the brain (e.g., Gottlieb, Oudeyer, Lopes, & Baranes, 2013; Panksepp, 1998; see discussion in Renninger & Hidi, 2016). In other words, all persons are hardwired to develop interest, and interest in any content may be supported to develop.

However, the research also indicates that whether interest, once triggered, is supported to develop depends on whether the task leads learners to find meaning in it, enabling them to make connection to their knowledge and value for the content. Some examples include the meaning Helen found in finger signing, meaning that students may be encouraged to identify for themselves in a course they are taking (Hulleman, Durik, Schweigert, & Harackiewicz, 2008; Hulleman & Harackiewicz, 2009), or meaning that emerges when learners are allowed or take charge of shaping class activities (Cobb & Hodge, 2004; Meyer & Turner, 2002).

The match between the strengths and needs of the learner and available support, described by Eccles and Midgley (1989) as the stage fit of the environment (see also Bronfenbrenner & Ceci's, 1994, discussion of the bioecological model), is critical to the development of interest. When support from the learning environment is lacking (or perceived to be lacking), interest can fall off, go dormant, or disappear altogether (Bergin, 1999). Renninger (2000), for example, described the case of a talented chess player who ceased playing chess because there was no one to challenge him. Renninger and Lipstein (2006; see also Renninger & Hidi, 2019) also reported that interest may decline when students do not perceive opportunities to connect to the work they are doing and/or feel that their ideas are respected and heard. Their findings are consistent with those of Kunter, Baumert, and Köller (2007), who found that within the same classroom there were students whose interest would develop and students whose interest would decrease. Kunter et al. observed that the development of interest is likely to be more related to students' personal experience of the classroom—for example, whether they feel they understand what is expected of them and have a teacher who is responsive and provides support for autonomy (see related discussions in Frenzel, Goetz, Pekrun, & Watt, 2010; Renninger, Kensey, Stevens, & Lehman, 2015; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). The stage fit of the person to the environment has been described as supporting feelings about the worth (the value, task interest, utility, cost) of continued engagement (e.g., Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006). Whether a person is able to make an independent decision to reengage has also been found to affect the relation between the affective and cognitive components of interest, a relation that affects the experience of interest (Ainley, 2007; Sansone & Thoman, 2005a, 2005b) as well as the likelihood that interest will develop and deepen (Renninger, 2000).

Although learners at all ages with varying experiences may develop new interests at any time, age also affects how and whether interest is likely to develop. Undergraduates, for example, may be able to self-generate ways in which to sustain interest in view of a task that they find boring by finding some reason that the task could be beneficial to them (e.g., Sansone et al., 1992). This capacity is related to their awareness of how they are thinking and learning in the situation (a boring task that needs to be completed, the need to pass a course that they are taking), their metacognitive awareness, and their ability to generate strategies to address it. Conversely, younger children find ways to continue to engage only if tasks are already of interest, although they also may be more open than older learners to trying to learn new topics or participate in new activities (Renninger, Sansone, & Smith, 2004). At about 8 to 10 years of age, they begin comparing their own capacities to those of others and then need a different form of support to persevere on tasks they have not yet tried or tasks they are aware others already do at a much more advanced level then they do (Renninger, 2009).

Conceptualizations of Interest Not Specifically Focused on Development

Understanding how interest can be supported to develop is of particular concern to those who support others to learn, whether in or outside the school context. However, the conceptualization of interest as a cognitive and affective motivational variable that develops is only one of the ways in which interest is defined and studied (see extended discussion in Renninger & Hidi, 2011). Krapp (2002, 2007), for example, describes interest development as a process

of developing one's identity. Other conceptualizations of interest reflect a range of research questions and, as a result, address different aspects of the way in which a person engages (or does not engage) with content to be learned. These perspectives contribute to understanding interest and its relation to learning, but may not address the development of interest per se. That said, however, each is a conceptualization on which the understanding of interest development builds.

Detailed considerations of interest can be described as focusing on emotion (e.g., Ainley, 2007; Ainley & Ainley, 2011; Ainley & Hidi, 2014; Moeller, Dietrich, Eccles, & Schneider, 2017; Silvia, 2006), task features and environment (e.g., Mayer, 2005; Sansone & Thoman, 2005a, 2005b; Sansone, Thoman, & Fraughton, 2015), value (e.g., Eccles, Fredricks, & Epstein, 2015; Schiefele, 2009; Wigfield et al., 2006), and vocational interest (e.g., Alexander, Johnson, Leibham, & Kelley, 2008; Holland, 1997; Lent, Brown, & Hackett, 1994; Rounds & Su, 2014). Conceptualizations of interest that focus on emotion are often concerned with the state of interest, rather than with interest as both a state and a predisposition to reengage particular content over time. Researchers have determined, for example, that mood, disposition, and situation combine to influence students' affective reactions to tasks (Ainley & Patrick, 2006) and that interest may be either pleasant or unpleasant (Turner & Silvia, 2006), but little is known about whether and how the intensity and valence of affect change with the development of interest.

Conceptualizations that have focused on interest in terms of task features or the environment have also pointed to the importance of the experience of interest to engagement. in the self-regulation of motivation model, for example, Sansone and her colleagues (Sansone & Thoman, 2005a, 2005b; Sansone et al., 2015; Sansone, Geerling, Thoman, & Smith, 2019) report that interest is essential to the feelings of competence that accompany this experience and the self-regulation of behaviors that enable goal attainment. Importantly, they find that it is not just the characteristics of the activity that are critical, but also the process of engaging the activity. They also report that when interest is low, students will work to make a task more interesting (e.g., by making it more congruent with their goals and/or using other strategies, such as exploratory engagement) if the goal is important.

Findings from studies of task features have also indicated that interest can be distracting (e.g., Mayer, Griffith, Jurkowitz, & Rothman, 2008) and have begun to provide information about whether and how the experience of interest varies with development. For example, Magner, Schwonke, Aleven, Popescu, and Renkl (2014) found that interest in task features varies with phase of interest. They demonstrated that learners' prior knowledge moderates how distracting a potential trigger for interest, or seductive detail such as decorative illustrations, might be. They reported that for those in earlier phases of interest development, decorative illustrations triggered, but did not maintain situational interest and derailed learning, whereas the learning of those in later phases of interest development was not hindered. Magner et al.'s study also provides an example of how a conceptualization of interest that targets specific information about experience/task features contributes to understanding the development of interest.

Conceptualizations that have focused on interest as value have further indicated that interest that is operationalized in terms of how much the respondent says he or she *likes* particular content will differentiate first in the expectancy-value framework (Wigfield et al., 2006) and is linked to intrinsic motivation (Schiefele, 2009). In cross-sectional work with middle and high school students, Denissen, Zarrett, and Eccles (2007) reported that self-concept of ability and interest are coupled, but they also point out that when achievement is introduced, there is a higher degree of coupling between self-concept of ability and achievement than between interest and achievement. However, given that value in these studies is examined at one point in time, little is understood about possible change in, for example, expectancy value as interest develops (see Wigfield & Cambria, 2010).

Conceptualizations that have focused on interest in terms of vocational or conceptual interest address the relation between a person's present abilities and possible occupations (e.g., Holland, 1997; see also Armstrong, Allison, & Rounds, 2008; Rounds & Su, 2014) or categories of children's interest engagement such as science or art (e.g., Alexander et al., 2008) and school readiness. One line of work within this framework draws on counseling psychology to suggest that environmental support can be provided to encourage those who currently lack interest to develop it (e.g., women who lack interest for engineering; Brown & Lent, 1996). Lent, Brown, and Hackett's (1994, 2000) social cognitive career theory describes interest development as determined by the individual's perceptions of his or her own competence, or ability to succeed.

Each of the conceptualizations discussed indicates that interest is always linked to a particular disciplinary content, object, event, or idea. The conceptualizations also all acknowledge the role of affect, or feelings, as a component of interest, but they tend to vary in the extent to which affect, knowledge, and value are the focus of inquiry and measurement. Some of the conceptualizations describe knowledge and value as components of interest (Ainley, 2007; Hidi & Renninger, 2006; Mayer, 2005; Sansone & Thoman, 2005a, 2005b; Silvia, 2006), whereas others focus on affect and value as established through cognitive evaluation (Krapp, 2005, 2007; Schiefele, 2009; Wigfield et al., 2006). Differences among the conceptualizations with respect to the role of knowledge reflect differences among research aims. The research questions being addressed do not necessarily assess change over time but instead focus on one or another aspect of interest that may be present and/or a factor in each phase of interest.

Measurement Considerations

There currently is no single correct measure or indicator of interest or interest development, and as Renninger and Hidi (2011) have noted, such a specification may not be possible because of differences in the structure of disciplinary domains, with some being more hierarchical than others (Lawless & Kulikowich, 2006) and/or differences in researchers' questions. To date, interest development has been measured using surveys (e.g., Chen, Darst, & Pangrazi, 1999; Häussler & Hoffmann, 2002; Linnenbrink-Garcia et al., 2010; Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005; Michaelis & Nathan, 2015; Rotgans & Schmidt, 2011; Schiefele, Krapp, Wild, & Winteler, 1993; Schraw, Bruning, & Svoboda, 1995) and behavioral measures, such as online experience sampling (Ainley, Hidi, & Berndorff, 2002), functional magnetic resonance imaging (Kim, Lee, & Bong, 2009), or participant observation (Nolen, 2007; Pressick-Kilborn & Walker, 2002; Renninger & Wozniak, 1985).

Interest has also been assessed based on participation (Azevedo, 2006; Barron, 2006; Fink, 1998) or membership (e.g., recreational figure skaters, see Green-Demers, Pelletier, Stewart, & Gushue, 1998; and mathematicians, Gisbert, 1998). However, Renninger, Cai, Lewis, Adams, and Ernst (2011) found that interest needs to be well developed for it to be accurately predicted by participation or membership alone. Their findings suggest the importance of triangulating assessments to accurately capture differences among phases of interest. For example, although triggered interest may be assessed using behavioral measures (e.g., observation, log file analysis), because respondents in earlier phases of interest development may not be aware that their interest has been triggered, it is not easily assessed using self-reports, especially in those earlier phases of development. Respondents are able to self-report on whether they work on more math problems than those that are assigned though, suggesting the utility of confirming and/or developing survey items that assess behavioral information.

Many researchers have assessed interest by asking respondents to rate how much they like particular content. This type of rating provides a distinction between the presence or absence of interest, but may not effectively distinguish between how developed a person's interest is, because emotional responses in earlier and later phases of interest are not likely to differ (see Ainley, 2017). Conceptualized as a variable that develops, interest has both cognitive and affective components. Given that there is likely to be little difference in how much a person in different phases of interest "likes" the content of interest and that a person may have developed expertise (e.g. an X-ray technician), but may or may not have a developed interest in it, assessment of interest development must also account for the cognitive component of interest (see discussion in Hidi & Renninger, 2006).

Hidi and Renninger (2006) noted that although the earliest phases and the state of interest may be characterized and assessed by affective response, the identification of developed interest must consider the relation between feelings, value, and knowledge, and changes in this relation might be expected with development. In their 2016 volume (Renninger & Hidi, 2016), they point to four indicators that can be used for purposes of assessing interest development. These include whether, compared to other activities and given the opportunity, a person will engage the content:

1. frequently;
2. with understanding or depth of knowledge;
3. voluntarily; and
4. independently (without others also being involved).

Considered together, these indicators provide reliable information about a person's phase of interest. They have been found to form a single factor ($\alpha = 0.91$, Renninger & Schofield, 2014). Individuals in earlier phases of interest development may often be identified by their infrequent engagement with

the content in question, their lack of knowledge, and their reluctance to voluntarily or independently participate, whereas those with more developed interest frequently engage and do so voluntarily, independently, and with depth. The four indicators have been used to develop items for self-reporting that distinguish among phases of interest (e.g. Cabot, 2014; Lipstein & Renninger, 2007; Michaelis & Nathan, 2015) and to track whether learners are in an earlier, or less developed, phase of interest or in a later, or more developed, phase of interest.

Research on Interest Development

Studies that track the behaviors of individuals over time (longitudinal studies) and studies of learners in earlier and/or later phases of interest (also reported as situational and individual, less developed and more developed, or low interest and high interest) provide our present understanding of interest development. We describe findings from these two types of studies separately because they offer different insights. Longitudinal studies yield rich, descriptive information that provides a basis for developing inductive models that can be used for theory-building, as well as the design of tasks and/or interventions. Studies that have examined earlier and/or later phases of interest focus on studying one or more aspects of findings identified in more descriptive data with samples and methods that allow findings to be generalized.

Here we review a parsimonious selection of longitudinal studies, in addition to studies focused on earlier and/or later phases of interest development, with particular attention to four questions central to supporting a triggered interest to develop: (a) the triggering of interest in both earlier and later phases of interest, (b) how and why interest is maintained once it has been triggered, (c) fluctuations in interest, and (d) shifts between phases in the development of interest. We then suggest the generative potential of thinking across studies that address different questions.

Longitudinal Studies

Interest development as described in studies that have tracked individuals over time is collected through interviews with the participant and/or other people in the participant's life, the development of portraits based on interviews, and/or surveys, experience sampling, course enrollments, and/or observation. Taken together, such studies describe the development of interest as primarily a sequential process that evolves through a person's interactions with other people and the design of the environment (e.g., tasks such as challenging reading materials, opportunities that the person can recognize).

TRIGGERS FOR INTEREST DEVELOPMENT

Longitudinal studies describe a changing relation between a person's affect and knowledge as interest develops. They also describe the triggering process and subsequent support as enabling a person to make connections to content in earlier phases of interest and to find opportunities to continue to develop understanding of content in later phases. Some examples include the following: the desire for parental approval and opportunities to pursue mathematics as triggers for an interest in mathematics (Gisbert, 1998), children's abilities to express themselves as members of a "literate community" in their classroom as triggers for developing an interest in reading and writing (Nolen, 2007), and instructional methods that led students to identify with Latin as triggers for an interest in Latin (Renninger et al., 2004).

Changes in the relation between affect and knowledge are also noted in later phases of development, when the interest being studied already exists. Some examples include the following: descriptions of self-initiated work with technology in which adolescents seek additional resources, create new activities, pursue structured learning, and develop mentoring/knowledge-sharing relationships (Barron, 2006; see also Barron, Gomez, Pinkard, & Martin, 2014); the dyslexic adolescent who develops an understanding of reading by focusing on reading about his or her already well-developed interest in chemistry (Fink, 1998); and business students whose interests were refined as they took advantage of new opportunities to continue to develop their understanding of business-related skills (Krapp & Lewalter, 2001). Findings from these studies indicate that once an interest is triggered and a connection to content is made, interest continues to develop, as long as there are opportunities and support for its continued development. However, as evidenced in Renninger, Ren, and Kern's (2018) case study of the ballerina, too much challenge can be overwhelming, even for a person with a well-developed interest. As interest develops, the triggers that promote interest development, as well as the supports that may be needed to enable its continued development, differ based on existing interest and experience.

SUSTAINING INTEREST, FLUCTUATIONS, AND SHIFTS BETWEEN PHASES

Examinations of the development of interest over time suggest that, once triggered, interest is sustained based on the availability of (a) opportunities to continue to learn and (b) support to become independent or autonomous. Such opportunities can take the form of finances, timing, or access (Ainley & Ainley, 2015; Azevedo, 2006, 2013a, 2013b; Barron, 2006; Barron, Kennedy-Martin, Takeuchi, & Fithian, 2009; Crowley, Barron, Knutson, & Martin, 2015), although the types of support or feedback required may depend on the phase of the learner's interest (Lipstein & Renninger, 2007, see Renninger & Hidi, 2019). Mismatches between a learner's phase of interest and available supports have been found to result in marginalization and lack of identification (e.g., Nolen, 2007), a decrease in feelings of competence (e.g., Azevedo, 2006), and the falling off of interest (Renninger & Lipstein, 2006). In contrast, shifts, or movement from one to another phase of interest are characterized as including increased feelings of competence, the acquisition of skills and knowledge (Nolen, 2007; Lipstein & Renninger, 2007; see discussion in Renninger & Hidi, 2016), and/or identification with the domain of interest (e.g, identification as a scientist, Chittum & Jones, 2017; see Krapp, 2003, 2005).

Assessed in terms of individual learners and their development over time, studies that have mapped pathways to interest development point to the critical role of environmental supports in triggering and sustaining interest (Alexander, Johnson, & Neitzel, 2019). As interest develops, the supports must shift from helping learners make connections to particular content to encouraging learners with more developed interest to fully engage, explore, and work with the content of interest (Renninger, 2010; Renninger & Hidi, 2019). The studies allow identification of recurrent patterns within the ecology of the larger learning environment and suggest that there are multiple points in development when support can be provided that enables interest to either develop and/or deepen (Alexander et al., 2019; see also Barron, 2006). Although the patterns reported in longitudinal studies are often descriptive and specific to particular contexts, the effort to consider replication and validation across studies such as those provided by Alexander et al. (2019), Barron et al. (2014), and Crowley et al. (2015) suggests that these findings are generalizable and hold insights for those seeking more targeted information about specific aspects of earlier and later phases of interest development.

Studies of Earlier and/or Later Phases of Interest

Studies of earlier and/or later phases of interest are often undertaken to address the relation of interest as a motivational variable to other variables (e.g., goals, self-efficacy), rather than interest development per se. They nonetheless contribute to understanding interest development, especially if considered in relation to findings from longitudinal studies. In studies of earlier and/or later phases of interest development, the sample of participants is partitioned into groups based on responses to survey items. Some studies have focused on participants in a particular phase of interest, and others have compared the responses of participants who are in different phases. Most often, these studies focus on earlier phases of interest and have measured interest in terms of affect and value, rather than knowledge. Taken together, these studies point to the importance of the relation among achievement, feelings of competence, and interest. They also suggest that their awareness of how they are learning and thinking in the situation, their metacognitive awareness, may be a critical support for interest development.

TRIGGERS FOR INTEREST DEVELOPMENT

Findings from studies addressing earlier and/or later phases of interest development have focused on (a) the impact of triggers for situational or individual interest on learning and (b) the experience of the learning environment as a contributor to interest.

Both situational interest and individual interest have been found to trigger interest. Situational interest has been found to promote reading comprehension and motivation among third graders (Guthrie et al., 2006), help high school students develop positive attitudes toward science (Palmer, 2009), and promote undergraduates' reading engagement and essay production (Flowerday, Schraw, & Stevens, 2004). Similarly, individual interest has been found to enable learners to persevere in working with content that is complex and challenging. For example, middle school students were found to be more likely to persevere in working on math problems into which an individual interest had been inserted as a context (e.g., basketball) than problems into which content of less-developed interest (e.g., football) were inserted (Renninger, Ewen, & Lasher, 2002; see also Hoffmann, 2002; Walkington & Bernacki, 2015).

Having interest has also been described as a buffering factor that helps students to cope with unfavorable learning conditions (Katz, Assor, Kanat-Maymon, & Bereby-Meyer, 2006). For example, Tsai et al. (2008) reported that the climate of the classroom (e.g., the levels of autonomy support, controlling behaviors) influenced those with less-developed interest more than those with well-developed interest. Similarly, in an experimental manipulation of triggers for interest in solving math problems, Durik and Harackiewicz (2007) found that a learner's level of interest for math influenced the impact of catch (collative factors) and hold (situational factors that sustain interest). Those individuals with less interest for mathematics showed more interest in the collative-rich environment that provided triggers for novelty and less interest in triggers for challenge, whereas those with more-developed interest for mathematics were negatively affected by triggers for novelty and positively influenced by triggers for challenge.

Findings such as these indicate both that potential triggers for interest differ when learners have more- and less-developed interest and that availability (and continued availability) of triggers may be particularly critical for those in earlier phases of interest development. They also suggest, as Schiefele and Csikszentmihalyi (1994) reported, that the association between interest and experience is independent of achievement and that changes in experience can affect interest (see also Pugh, Linnenbrink-Garcia, Koskey, Stewart, & Manzey, 2010). However, Schiefele and Csikszentmihalyi (1995) also reported a correlation between grades and interest that, like Jacobs, Lanza, Osgood, Eccles, and Wigfield's (2002) findings, points to links between grades and valuing as contributing to the experience of interest.

Sansone and her colleagues' work suggests that interest experience reliably predicts task choice and persistence and is essential to self-regulation (e.g., Sansone & Thoman, 2005a, 2005b; see also Sansone et al., 2015, 2019). With interest, the learner has a clear goal and is able to self-generate or trigger interest. Thus, although present perceptions and values may inform present interest, the experience of interest can change through the process of triggering that is provided either by other people or situations (e.g., Hulleman et al., 2008; Mitchell, 1993; Palmer, 2009; Palmer, Dixon, & Archer, 2016) or by individuals who are in a position to self-generate interest (e.g., by finding a reason to persevere; Sansone et al., 1992, 2019).

SUSTAINING INTEREST AND FLUCTUATIONS AND SHIFTS IN INTEREST DEVELOPMENT

Studies of earlier and/or later phases of interest development suggest that situational factors, challenge, and personal investment are potential triggers for sustaining interest, and they provide a basis for shifts that occur in interest development. For example, experiences in which students are led to explore and work with the everyday meaning of science concepts in new ways can promote meaningfulness and sustain engagement (e.g., Palmer, 2004, 2009; Palmer et al., 2016; Pugh et al., 2010; Pugh, Linnenbrink-Garcia, Phillips, & Perez, 2015). The design of the tasks can also explicitly support learners to reflect on activity and position them to set goals, ask questions, and want to know more (e.g., Renninger et al., 2014).

Whether interest is sustained and continues to develop appears to be linked to learners' perceptions of their experiences, as well as their abilities to set goals for themselves and self-regulate (see Sansone & Thoman, 2005b; Sansone et al., 2015). Harackiewicz et al.'s (2008) findings indicate, for example, that the process of triggering interest and adopting goals differs for those who come to class with an already developed interest and those who do not. They found that undergraduates with low initial interest who reported having their interest triggered were also those who experienced shifts in the development of interest, suggesting that the triggering of interest can promote mastery goals and that mastery goals can also promote interest development.

Harackiewicz et al. (2008) also found, however, that the simple presence of a trigger did not predict continued interest. Rather, the triggering of interest in addition to students' final grades in the course predicted their continued interest. These findings suggest the importance of both mastery and performance goals to the development of interest (see Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002; Harackiewicz, Barron, Tauer, & Elliot, 2002). Moreover, analyses to examine the relation between interest (measured in terms of feelings and value) and background knowledge in the Harackiewicz et al. (2008) study revealed that initial interest was a particularly strong predictor of continued interest when paired with a high level of background knowledge, indicating the importance of content knowledge for interest development. Studies also indicate that when learners have low interest and little knowledge, interest can be triggered by supporting them to identify the utility of classroom content (e.g., biology), which results in developing

interest, increases in performance, and subsequent enrollment in similar coursework (e.g., Hulleman & Harackiewicz, 2009; Hulleman, Kosovich, Barron, & Daniel (2016); see also Harackiewicz, Tibbetts, Canning, & Hyde, 2014).

Interest that is triggered may continue to develop, but may also fluctuate. Consistent with Harackiewicz and her colleagues' findings (e.g., Harackiewicz, Barron, Tauer, et al., 2002; Harackiewicz et al., 2008), Denissen et al. (2007) found that students between 6 and 17 years of age felt competent and interested in the subjects in which they achieved and in which they perceived themselves to have ability. They also found that as students get older, there is increased coordination of achievement, self-concept of ability, and interest, suggesting an increasingly influential role of student perceptions when the content with which they are working in school also reflects increases in difficulty (see related discussion in Hidi & Ainley, 2008).

The evidence suggests that when a learner's interest is triggered, it can be sustained, but if interest fluctuates, this is a result of the learner's perceptions or experience of the environment (e.g. Renninger, Ren, & Kern, 2018). Noted but not specifically examined in studies of earlier and/or later phases of interest development is the role of the learner's metacognitive awareness. Discussions have centered instead on perceptions or experience of the environment and whether the learner responds to potential triggers or opportunities.

Harackiewicz et al.'s (2008) findings suggest that when learners are able to report having a triggered interest, their interest can be expected to develop. An emergent finding of this review, which Harackiewicz et al. (2008) did not point out, is that participants who report having their interest triggered on a survey must have at least some level of metacognitive awareness. This is not to say that interest cannot develop without metacognition, but rather that interest can be expected to develop if metacognition is present. Without metacognitive awareness, the learner can be supported to engage with content, but may lack self-direction and need additional support to engage.

Study Complementarity: A Source of Validation and Insight

Reviewing articles and chapters for this chapter called our attention to the range of studies that contribute to the present understanding of interest development. It also pointed to the importance of considering study complementarity as a source of validation and insight about interest development. In this section of this chapter, we review the questions, methods, and findings from two solid and seemingly different studies reported by Frenzel et al. (2010) and Pugh et al. (2010). We use these two studies to illustrate study complementarity. We note that two other studies could as easily have been selected for this discussion; our choice was informed by the differences of methods employed in these two studies and the similarity of the age group that each study addressed.

Frenzel et al.'s (2010) study is a quantitative longitudinal study of early adolescents' mathematics interest; Pugh et al.'s (2010) study is a short-term qualitative study of high school students' transformative experiences with biology. Both studies assess the trajectory of interest development. Whereas Frenzel et al.'s (2010) study implies that the students' environment (e.g., teachers, parents, school) may influence and account for differences in their achievements and interest trajectories, Pugh et al.'s (2010) study highlights the role of individual learner characteristics in interest development. Together, these studies suggest that interest development involves both internal and external factors; their joint consideration also points to issues that research on interest development must still address.

FRENZEL, GOETZ, PEKRUN, AND WATT (2010)

Frenzel et al. (2010) reported on a longitudinal study of the mathematical interests of 3,193 students (51% female) in grades 5 to 9 in the German school system, based on surveys administered to the students and their parents. Using Likert scales assessing feelings and value to measure interest, the researchers addressed four issues: (a) the characteristics of trajectories of interest development in mathematics, (b) the role of gender in the development of interest for mathematics, (c) the role of ability grouping in interest development, and (d) the role of the values of other people in the development of interest for mathematics.

Frenzel et al. (2010) predicted that students would experience a generalized loss of interest across time. They hypothesized that students' intrinsic motivations for learning were likely to be in increasing conflict with school-ordained restrictions such as required courses, increased task complexity, and demands for academic effort and achievement. Frenzel et al. focused on mathematics, noting that mathematics has long been considered a field preferred by males. They predicted that gender would influence the level of mathematics interest in that

females would have less interest than males and that the level of female and male interest would not affect the expected decline in the trajectory of interest development, given findings suggesting gender differences in the level of interest but not in the trajectory of its development (e.g., Fredricks & Eccles, 2002; Jacobs et al., 2002; Watt, 2004).

Frenzel et al. (2010) also predicted that ability grouping would impact interest development based on Marsh's (1987) findings from a study of the big fish–little pond effect, which suggests negative effects for students placed into high-achievement groups, and positive effects of placement into low-achievement groups. Taking advantage of the organization of the German school system, which tests and places students into one of three academic tracks based on academic achievement by the fourth grade, Frenzel et al. posited that students in Hauptschule (the lowest track) would report higher interest levels than students in either Realschule (the middle track) or Gymnasium (the highest track), because of the pressure in Realschule and Gymnasium to focus on achievement instead of personal development.

Finally, based on the findings of social cognitive theorists (e.g., Eccles, Wigfield, Harold, & Blumenfeld, 1993; Pekrun, 2000), Frenzel et al. (2010) predicted that other people such as family, classmates/peers, and teachers would influence the formation of students' values and interest for mathematics. Family members, especially parents, have been found to be role models for their children's eventual interests and educational values (Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005) and students can be expected to develop interests and values similar to those of their parents (Jacobs & Eccles, 2000).

Findings from Frenzel et al.'s (2010) study revealed an overall decline in mathematical interest over time, regardless of variables such as gender. In terms of gender, Frenzel et al. reported that girls had a lower initial level of interest, as expected. There were no differences between the shapes of the trajectories of girls and boys, suggesting that the areas of decline and stabilization on the growth trajectories may be the result of an intensification at earlier ages. In addition, differences were identified in the level of interest of students in each of the different ability groups. General/universal longitudinal interest declines aside, students in Hauptschule in grade 5 had slightly lower initial levels of interest, but by grade 9 had managed to sustain interest, whereas students in both Realschule and Gymnasium evinced steeper declines in interest levels, leveling out at a lower level than Hauptschule students by grade 9. Finally, while family, peer, and teacher influences affected the formation of students' interest, it appears that, based on an assessment of interest trajectories, they did not influence the development of interest.

PUGH, LINNENBRINK-GARCIA, KOSKEY, STEWART, AND MANZEY (2010)

Pugh et al. (2010) reported on a short-term study of transformative experience among 166 (66% female) 9th- and 10th-grade biology students, where transformative experience is characterized by "motivated use, expansion of perception, and experiential value" (p. 7) and interest and task value are described as supporting conceptual change (Dole & Sinatra, 1998). Prestudy, poststudy, and follow-up assessments of students' science knowledge, identity, and goals were undertaken using survey data. Interest was not assessed independently, but as part of the construct of experiential value; Likert items were used to assess student opinion about the value and utility of information about natural selection.

Pugh et al.'s (2010) research questions focused on three issues: (a) the prevalence of transformative experiences among high school biology students learning about natural selection; (b) the relation among transformative experience, science identity, and mastery goal orientation; and (c) the relation between transformative experience and both initial and enduring conceptual change and transfer. Based on findings from Pugh (2004), Pugh et al. (2010) described transformative experiences as occurring when students are motivated to apply outside the classroom what they have learned in the classroom, experiences that led to expanded perception and value. These findings suggest that transformation is best measured by observing changes in students' conceptual understandings of science and whether they transfer their learning to other aspects of their lives, see aspects of the world in new ways, and find value in doing so (Pugh, 2004). Like findings from Girod, Twyman, and Wojcikiewicz's (2010) work with fifth graders, Pugh (2002) showed that biology students who had transformative experiences had more gains in conceptual understanding than those who did not. In the study examined here, Pugh and his colleagues (Pugh et al., 2010) sought to explore transformative experiences in an expanded sample and to explore science identity and achievement goal orientation as predictors of transformative experience. They chose to focus on natural selection

in the biology classroom because this is a topic about which students often have misconceptions.

Based on both Girod and Wong (2002) and Pugh (2004), the researchers expected that students who identified as having had transformative experiences were also those who saw the relevance of the science being taught. They conceptualized interest in this context in terms of value and science identity as composed of one's prior knowledge and one's identification with science as a strength or weakness. When students believed that they had a strong science identity, it was expected that they would thus see the relevance of the science unit being taught and were more likely to undergo transformative experiences (Girod & Wong, 2002; Pugh, 2004).

Thus, Pugh et al. (2010) predicted that students with a mastery goal orientation would be more likely to report transformative experiences, given the focus of mastery goal orientation on learning. Pugh et al. (2010) also expected that students who either strongly identify with science or have a mastery approach toward learning would be more likely to experience transformative experiences than those with a less defined science identity and a performance approach (i.e., displaying competence but not necessarily comprehension).

Pugh et al. (2010) found that both science identity and mastery goal orientations were positively associated with transformative experience. Students who both identified with science and had a mastery approach to learning were more likely to experience transformative experiences; they retained information and were able to independently apply it outside the classroom. However, students with initially higher levels of knowledge about the information taught in the unit also reported having more transformative experiences, suggesting that the acquisition and development of knowledge and interest (defined as value and utility) may be mutually reinforcing.

Their results further indicated that students with a mastery goal orientation were more likely to report experiencing transformative experiences and that mastery goal orientation mediated the relationship between science identity and transformative experience when prior science knowledge related to the unit taught was controlled. In other words, a strong science identity predicted a stronger endorsement of goal orientation, which in turn predicted the occurrence of transformative experiences. It appears that mastery orientation increased the likelihood of transformative experiences. On the strength of these findings, Pugh et al. (2010) pointed to the role of individual characteristics in the development of interest.

COMPLEMENTARY ASPECTS OF THE FRENZEL ET AL. (2010) AND PUGH ET AL. (2010) STUDIES

The findings of the Frenzel et al. (2010) and Pugh et al. (2010) studies mirror and extend discussions of interest development. Together, their findings suggest that, at least for adolescents, interest develops in relation to both academic achievement and feelings of competence, and central to this is the balance and personalizing of external and internal, environmental and individual factors.

Frenzel et al.'s (2010) findings confirm the existence of a general decline in interest over time spent in school and the influence of ability groups on students' interest development. Students in Hauptschule (the lower track) showed less steep declines in interest over time, compared to students in Realschule and Gymnasium. Frenzel et al. noted that this might be a result of the less competitive atmosphere with fewer achievement-oriented demands in Hauptschule compared to Realschule and Gymnasium. These findings suggest that the learning environment has a critical role as a support for (or constraint on) academic development, interest, and performance.

Similarly, Pugh et al.'s (2010) findings point to the importance of the learning environment in promoting comprehension and transfer, suggesting the further need to attend to the role of learner characteristics in the development of interest. When the researchers controlled for prior knowledge, students with a mastery approach to learning were found to have more comprehension and a greater ability to retain and transfer what they had learned to other aspects of their lives. These findings further suggest that a mastery goal orientation may compensate for less than ideal situational factors such as unsupportive environments, limited opportunities, and grade-oriented pressure. It also appears that whether interest develops depends on the learner: It may be the individual's approach to learning that most influences both comprehension and transfer.

Frenzel et al.'s (2010) and Pugh et al.'s (2010) studies also indicated that both situational and individual factors can result in a falling off of interest. According to the Frenzel et al. study, placement into a high-achievement ability group negatively influenced interest development, whereas placement in a low-achievement ability group had a positive effect. The interest levels of Hauptschule students declined at a slower rate than that of Realschule or

Gymnasium students and eventually stabilized toward the later grades of high school. Because the declines in interest occurred regardless of the student's initial interest level, this suggests that the right combination of environmental factors and amount of external pressure can cause someone's interest to change, whether positively or negatively. Similarly, Pugh et al. (2010) found that intrinsic motivation, such as a mastery goal orientation, increased the likelihood of transformative experiences, more advanced conceptual understanding, and the transfer of learning.

KNOWLEDGE, A COMPONENT OF DEVELOPING INTEREST

Frenzel et al. (2010) used items to assess interest that tapped feelings and value, as well as the participants' knowledge: "I would like to find out more about some of the things we deal with in our mathematics class" and "I like to read books and solve brainteasers related to mathematics" (p. 532). Pugh et al.'s (2010) decisions to assess interest using items addressing feelings and value (e.g., "During science class, I think the stuff we are learning about adaptation and/or natural selection is interesting" [p. 22]) and to control for prior knowledge influence what they may be able to say about interest development. If interest develops through phases, and if transitions between phases of interest depend on developing understanding, then knowledge must be included in measures intended to distinguish between earlier and later phases of interest development. Pugh et al.'s (2010) findings provide information about the roles of knowledge and value in the process of making connections to content to be learned. However, their findings do not explicitly address differences between those in earlier and later phases of interest and their abilities to pose questions, seek answers, and so forth. It is possible that some of the students they studied were in later phases of interest development, and that distinguishing among them could further inform understanding about how to promote comprehension and transfer based on this difference.

Both Frenzel et al. (2010) and Pugh et al. (2010) described their studies of interest in terms of low and high interest, yet the relation between their outcomes and interest theory suggest that what they are each describing could differ. Frenzel et al. have distinguished between earlier and later phases of interest for mathematics because they have included knowledge in their assessment of interest. By contrast, Pugh et al. appear to be describing either earlier and later phases of situational interest (triggered situational and maintained situational) or an earlier phase, consisting of triggered situational and maintained situational interest, and a later phase of emerging individual interest (see Table 12.1).

Consistent with descriptions of students in earlier phases of interest as mapped by Lipstein and Renninger (2007; see also Renninger & Riley, 2013), Frenzel et al. (2010) and Pugh et al. (2010) suggested that it is the student who ultimately makes use of available supports, and whether students make this choice depends on whether they make personalized, individualized connections to content and whether their learning environment has provided the opportunity and/or supported them to do so. This is an important point.

Although personalized content has for some time been recognized as important in generating interest (e.g., Mitchell, 1993), the findings from these two studies indicate that it is the learner, not the teacher or the researcher, who decides what is meaningful—they also suggest that learners determine what is meaningful regardless of their phase of interest development. Whether students are able to take advantage of available resources may have to do with how they understand the task or situation (goals and expectations), including their ability to recognize the utility of the particular resources or practices that would allow them to realize goals that are set for them by others. These findings further suggest that the degree to which learners are metacognitively aware of their interest and its malleability could be critical. Having an interest is not the same as being metacognitively aware of the role of interest in one's learning. Supporting the development of learners' metacognitive awareness of their interest may well enable goal setting and self-regulation that could enhance the experience of interest, as well as its development and ensuing achievement.

Conclusions

The studies of Frenzel et al. (2010) and Pugh et al. (2010) pointed to some potentially critical aspects of interest development, particularly the roles of situational influences such as the achievement demands of the learning environment and experiential valuing. Like the other studies of earlier and/or later phases of interest development, they also suggested a role for the level, or degree, of learner's metacognitive awareness of interest as informing the types of supports the learner needs to support his or her interest to develop.

Together, these aspects of interest development form the basis of an inductive model for

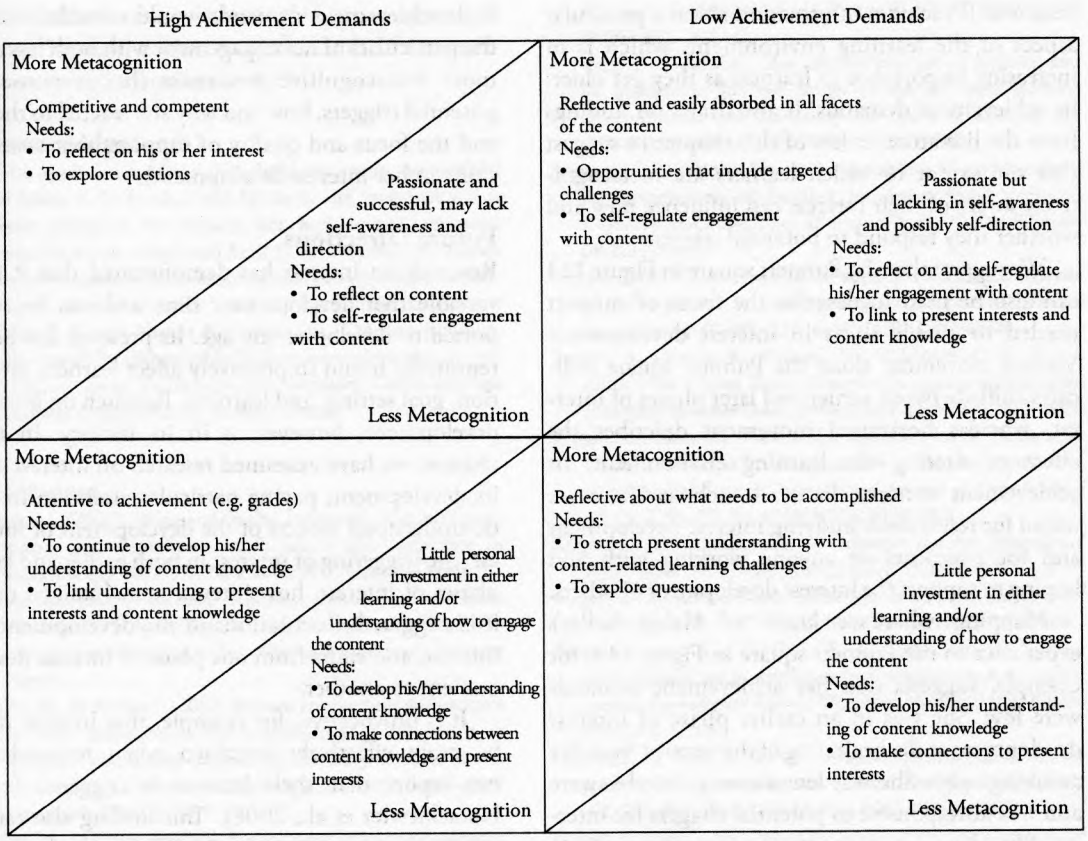

Figure 12.1 Punnett square of the possible relations among learner phase of interest, metacognitive abilities, and achievement demands of the learning environment.

understanding the relations among the learner's phase of interest, achievement demands of the learning environment, and metacognitive awareness. We present these using a Punnett square,[2] as depicted in Figure 12.1. The phase of a learner's interest forms one dimension and the achievement demands of the learning environment form the other. The level of the learner's metacognition is also included in each quadrant. Framed in this way, it appears that metacognitive awareness, in terms of both reflection on content and self-regulation of engagement, should benefit the learner and supports interest to develop. Development of content knowledge is also understood to support learners to make meaningful connections to the content, regardless of their initial phase of interest. However, organized in this way, it also appears that the achievement demands of the learning environment may benefit or hinder the learner's ability to make connections to the content, questioning, and seeking additional information and understanding. If learners are hindered, their content knowledge may develop but their interest may not, thereby compromising their possibilities for deeper learning.

To date, research on interest development has tended to focus on one or another aspect of interest and/or its development, using different measures and methods, sometimes resulting in seemingly contradictory findings and conclusions. We suggest the utility of identifying complementarities among findings—a consideration that also requires attending to the way in which interest and its development are conceptualized and measured, how they are studied, with which populations (age and experience), and in what type of context (domain of study, achievement expectations, etc.).

The Punnett square depicted in Figure 12.1 draws on findings indicating that interest develops through the interaction of the learner and the environment, and enables the identification of possible

[2] A Punnett square is a diagram, or tool, used by biologists to predict outcomes of a particular cross, or breeding, experiment.

relations. It includes information about a particular aspect of the learning environment, which is of increasing importance to learners as they get older: its achievement demands. It also draws on findings from the literature review of this chapter to suggest that the extent to which learners are metacognitively aware of their interest can influence how and whether they respond to potential triggers.

We suggest that the Punnett square in Figure 12.1 can also be used to describe the focus of support needed to enable shifts in interest development. Vertical movement along the Punnett square indicates shifts between earlier and later phases of interest, whereas horizontal movement describes the effect of altering the learning environment, or achievement context. Patterns such as these are useful for researchers studying interest development and for educators or anyone working with and hoping to support the interest development of others.

Mapping what we know of Helen Keller's experience to the Punnett square in Figure 12.1, for example, suggests that her achievement demands were low. She was in an earlier phase of interest development at the beginning of this excerpt from her autobiography: She was less metacognitively aware and was unresponsive to potential triggers for interest. She then shifted to be more metacognitively aware of her interest in communication and more developed in her interest in communication.

Helen's interest developed outside the school environment; it could be said to have been a context with low achievement demands and that Anne, her tutor, provided appropriate types of support to allow her interest to develop. Based on Helen's account, she appears to have almost skipped the phase of maintained situational interest once she made the connection between finger signing and the water, suggesting that perhaps the maintaining of interest is an artifact of school-based learning (see similar findings reported in Renninger & Riley, 2013). Reflecting on Helen's case and the overviews of the literature provided, we note that Helen is significantly younger than the adolescent learners of the Frenzel et al. (2010) and Pugh et al. (2010) studies. This suggests that for Helen, the development of her interest in communication was possibly easier than it might have been for an older, more self-conscious student (see Renninger, 2009).

Questions that also could be considered on the basis of the quadrants of the Punnett square in Figure 12.1 include the following: whether Helen's age changes the trajectory of interest development in some way; what difference a context that provided high achievement demands would contribute; and the particulars of her engagement with both less and more metacognitive awareness (her response to potential triggers, how and why she reacted to them, and the focus and quality of supports that enabled shifts in her interest development).

Future Directions

Research on interest has demonstrated that it is a variable that develops over time and can be supported to develop at any age. Its presence has been repeatedly found to positively affect learners' attention, goal setting, and learning. Research on interest development, however, is in its infancy. In this chapter, we have examined research on interest and its development, paying particular attention to little-understood aspects of the development of interest: the triggering of interest in both earlier and later phases of interest, how interest is maintained once it is triggered, fluctuations in the development of interest, and shifts from one phase of interest development to another.

It is provocative, for example, that interest may be more effectively sustained when respondents can report that their interest is triggered (e.g., Harackiewicz et al., 2008). This finding also raises other questions, for example, Why and when is a potential trigger likely to come to the attention of a learner? Are potential triggers for interest the same in all disciplinary contexts, in naturally occurring as well as experimental contexts? Do potential triggers (e.g., novelty) hold the same meaning for learners in one versus another phase of interest and at different ages?

Similarly, findings suggesting that fluctuations in interest are likely to be caused by learners' perceptions or experience of the environment are critical and raise questions for further study. For example, Are there particular learner characteristics, or configurations of learner characteristics, that contribute to how the environment is perceived or experienced and whether interest can be expected to develop? What types of environmental supports are needed for learners in different phases of interest? What is the role of metacognition in the development of interest and how might it be fostered?

We suggest that progress in understanding interest and its development involves not only additional study, but also revisiting the complementarity, differences, and challenge posed by the review of existing findings. The Punnett square depicted in Figure 12.1 points to relations suggested by this review that are likely and need further elaboration.

These include the relations among the phase of learner interest, achievement demands of the environment, and metacognition.

Acknowledgments

We are appreciative of the thoughtful comments we received from Jessica E. Bachrach, Heidi M. Kern, and Jong-Seok Lee at different phases in this chapter; fact-checking and comments provided by Kevin J. Pugh and Anne C. Frenzel, the lead authors on the two studies we describe to illustrate study complementarity; and editorial support provided by Allison L. Ganett, William F. Kenny, Nadine Kolowrat, and J. Melissa Running. We also gratefully acknowledge funding for work on this chapter from a Joel Dean Faculty–Student Research Grant and the Swarthmore College Faculty Research Fund.

References

Ainley, M. (2007). Being and feeling interested: Transient state, mood, and disposition. In P. Schutz (Ed.), *Emotion in education* (pp. 141–157). New York, NY: Academic Press.

Ainley, M. (2017). Interest: Knowns, unknowns, and basic processes. In P. A. O'Keefe & J. M. Harackiewicz (Eds.), *The science of interest* (pp. 3–24). Cham, Switzerland: Springer Nature.

Ainley, M., & Ainley, J. (2011). Student engagement with science in early adolescence: The contribution of enjoyment to students' continuing interest in learning about science. *Contemporary Educational Psychology, 36*, 4–12. doi:10.1016/j.cedpsych.2010.08.001

Ainley, M., & Ainley, J. (2015). Early science learning experiences: Triggered and maintained interest. In K. A. Renninger, M. Nieswandt, & S. Hidi (Eds.), *Interest in mathematics and science learning* (pp. 17–33). Washington, DC: American Educational Research Association.

Ainley, M., & Hidi, S. (2014). Interest and engagement. In R. Pekrun and L. Linnenbrink-Garcia (Eds.), *Handbook of emotions and education* (pp. 205–227). New York, NY: Taylor & Francis.

Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology, 94*, 545–561. doi:10.1037//0022-0663.94.3.545

Ainley, M., & Patrick, L. (2006). Measuring self-regulated learning processes through tracking patterns of student interaction with achievement activities. *Educational Psychology Review, 18*, 267–286. doi:10.1007/s10648-006-9018-z

Alexander, J. M., Johnson, K. E., Leibham, M. E., & Kelley, K. (2008). The development of conceptual interests in young children. *Cognitive Development, 23*, 324–334. doi:10.1016/j.cogdev.2007.11.004

Alexander, J. M., Johnson, K. E., & Neitzel, C. (2019). Multiple points of access for supporting interest in science. In K. A. Renninger & S. E. Hidi (Eds.), *The Cambridge handbook of motivation and learning* (pp. 312–352). Cambridge, UK: Cambridge University Press.

Armstrong, P. I., Allison, P., & Rounds, J. (2008). Development and initial validation of brief public domain RIASEC marker scales. *Journal of Vocational Behavior, 73*, 287–299. doi:10.1016/j.jvb.2008.06.003

Azevedo, F. S. (2006). Personal excursions: Investigating the dynamics of student engagement. *International Journal of Computers for Mathematical Learning, 11*, 57–98. doi:10.1007/s10758-006-0007-6

Azevedo, F. S. (2013a). The tailored practice of hobbies and its implication for the design of interest-based learning environments. *The Journal of the Learning Sciences, 22*, 462–510. doi:10.1080/10508406.2012.730082

Azevedo, F. S. (2013b). Knowing the stability of model rockets: An investigation of learning in interest-based practices. *Cognition and Instruction, 31*, 345–374. doi:10.1080/07370008.2013.799168

Barron, B. (2006). Interest and self-sustained learning as catalysts of development: A learning ecology perspective. *Human Development, 49*, 193–224. doi:10.1159/000094368

Barron, B., Gomez, K., Pinkard, N., & Martin, C. K. (Eds.). (2014). *The Digital Youth Network: Cultivating digital media citizenship in urban communities.* Cambridge, MA: MIT Press.

Barron, B., Kennedy-Martin, C., Takeuchi, L., & Fithian, R. (2009). Parents as learning partners in the development of technological fluency. *International Journal of Learning and Media, 1*, 55–77. doi:10.1162/ijlm.2009.0021

Bergin, D. (1999). Influences on classroom interest. *Educational Psychologist, 34*, 87–98. doi:10.1207/s15326985ep3402_2

Bergin, D. A. (2016). Social influences on interest. *Educational Psychologist, 51*, 7–22. doi:10.1080/00461520.2015.1133306

Bronfenbrenner, U., & Ceci, S. J. (1994). Nature–nurture reconceptualized in developmental perspective: A biological model. *Psychological Review, 101*, 568–586. doi:10.1037/0033-295X.101.4.568

Brown, S., & Lent, R. (1996). A social cognitive framework for career choice counseling. *The Career Development Quarterly, 44*, 355–367. doi:10.1002/j.2161-0045.1996.tb00451.x

Cabot, I. (2014). *The four-phase model of interest development: Elaboration of a measurement instrument.* Poster presented at Current Approaches to Interest Measurement, American Educational Research Association, Philadelphia, PA.

Chen, A., Darst, P. W., & Pangrazi, R. P. (1999). What constitutes situational interest? Validating a construct in physical education. *Measurement in Physical Education and Exercise Science, 3*, 157–180. doi:10.1207/s15327841mpee0303_3

Chittum, J. R., & Jones, B. D. (2017). Identifying pre–high school students' science class motivation profiles to increase their science identification and persistence. *Journal of Educational Psychology, 109*, 1163–1187. doi:proxy.swarthmore.edu/10.1037/edu0000176

Cobb, P., & Hodge, L. (2004, June). *An initial contribution to the development of a design theory of mathematical interests: The case of statistical data analysis.* Paper presented at Design Theories of Interest, Motivation, and Engagement for the Learning Sciences, Sixth International Conference of the Learning Sciences, Santa Monica, CA.

Crouch, C. H., Wisittanawat, P., Cai, M., & Renninger, K. A. (2018). Life science students' attitudes, interest, and performance in introductory physics for life sciences (IPLS): An exploratory study. *Physical Review Physics Education Research, 14*(1). doi:10.1103/PhysRevPhysEducRes.14.010111.

Crowley, K., Barron, B. J., Knutson, K., & Martin, C. (2015). Interest and the development of pathways to science. In K. A. Renninger, M. Nieswandt, & S. E. Hidi (Eds.), *Interest in mathematics and science learning and related activity* (pp. 297–313). Washington, DC: American Educational Research Association.

Denissen, J. H., Zarrett, N. R., & Eccles, J. S. (2007). "I like to do it, I'm able, and I know I am": Longitudinal couplings

between domain-specific achievement, self-concept, and interest. *Child Development, 78*, 430–447. doi:10.1111/j.1467-8624.2007.01007.x

Dole, J. A., & Sinatra, G. M. (1998). Reconceptualizing change in the cognitive construction of knowledge. *Educational Psychologist, 33*, 109–128. doi:10.1080/00461520.1998.9653294

Durik, A., & Harackiewicz, J. M. (2007). Different strokes for different folks: How individual interest moderates the effects of situational factors on task interest. *Journal of Educational Psychology, 99*, 597–610. doi:10.1037/0022-0663.99.3.597

Eccles, J. S., Fredricks, J. A., & Epstein, A. (2015). Understanding well-developed interests and activity commitment. In K. A. Renninger, M. Nieswandt, & S. Hidi (Eds.), *Interest in mathematics and science learning* (pp. 315–330). Washington, DC: American Educational Research Association.

Eccles, J. P., & Midgley, C. (1989). Stage/environment fit: Developmentally appropriate classrooms for early adolescents. In R. Ames & C. Ames (Eds.), *Research on motivation in education* (Vol. 3, pp. 139–181). New York, NY: Guilford Press. doi:10.1037/0003-066X.48.2.90

Eccles, J., Wigfield, A., Harold, R. D., & Blumenfeld, P. (1993). Age and gender differences in children's self- and task perceptions during elementary school. *Child Development, 64*, 830–847. doi:10.2307/1131221

Fink, R. (1998). Interest, gender, and literacy development in successful dyslexics. In L. Hoffmann, A. Krapp, K. A. Renninger, & J. Baumert (Eds.), *Interest and learning: Proceedings of the Seeon Conference on Interest and Gender* (pp. 402–408). Kiel, Germany: IPN. doi:10.1007/s11881-998-0014-5

Flowerday, T., Schraw, G., & Stevens, J. (2004). The role of choice and interest in reader engagement. *The Journal of Experimental Education, 72*, 93–114. doi:10.3200/JEXE.72.2.93-114

Fredricks, J. A., & Eccles, J. (2002). Children's competence and value beliefs from childhood through adolescence: Growth trajectories in two male-sex-typed domains. *Developmental Psychology, 38*, 519–533. doi:10.1037/0012-1649.38.4.519

Frenzel, A. C., Goetz, T., Pekrun, R., & Watt, H. M. G. (2010). Development of mathematics interest in adolescence: Influences of gender, family, and school context. *Journal of Research on Adolescence, 20*, 507–537. doi:10.1111/j.1532-7795.2010.00645.x

Girod, M., Twyman, T., & Wojcikiewicz, S. (2010). Teaching and learning science for transformative, aesthetic experience. *Journal of Science Teacher Education, 21*, 801–824. doi:10.1007/s10972-009-9175-2

Girod, M., & Wong, D. (2002). An aesthetic (Deweyan) perspective on science learning: Case studies of three fourth graders. *The Elementary School Journal, 87*, 574–587. doi:10.1086/499700

Gisbert, K. (1998). Individual interest in mathematics and female gender identity: Biographical case studies. In L. Hoffmann, A. Krapp, K. A. Renninger, & J. Baumert (Eds.), *Interest and learning: Proceedings of the Seeon Conference on Interest and Gender* (pp. 387–401). Kiel, Germany: IPN.

Gottlieb, J., Oudeyer, P-Y., Lopes, M., & Baranes, A. (2013). Information seeking, curiosity and attention: Computational and neural mechanisms. *Trends in Cognitive Science, 17*, 585–596. doi:10.1016/j.tics.2013.09.001

Green-Demers, I., Pelletier, L. G., Stewart, D. G., & Gushue, N. R. (1998). Coping with the less interesting aspects of training: Toward a model of interest and motivation enhancement in individual sports. *Basic and Applied Social Psychology, 20*, 251–261. doi:10.1207/s15324834basp2004_2

Guthrie, J. T., Wigfield, A., Humenick, N. H., Perencevich, K. C., Taboada, A., & Barbosa, P. (2006). Influences of stimulating tasks on reading motivation and comprehension. *Journal of Educational Research, 99*, 232–247. doi:10.3200/JOER.99.4.232-246

Harackiewicz, J. M., Barron, K. E., Pintrich, P. R., Elliot, A. J., & Thrash, T. M. (2002). Revision of achievement goal theory: Necessary and illuminating. *Journal of Educational Psychology, 94*, 638–645. doi:10.1037/0022-0663.94.3.638

Harackiewicz, J. M., Barron, K. E., Tauer, J. M., & Elliot, A. J. (2002). Predicting success in college: A longitudinal study of achievement goals and ability measures as predictors of interest and performance from freshman year through graduation. *Journal of Educational Psychology, 94*, 562–575. doi:10.1037//0022-0663.94.3.562

Harackiewicz, J. M., Durik, A. M., Barron, K. E., Linnenbrink, L., & Tauer, J. M. (2008). The role of achievement goals in the development of interest: Reciprocal relations between achievement goals, interest, and performance. *Journal of Educational Psychology, 100*, 105–122. doi:10.1037/0022-0663.100.1.105

Harackiewicz, J. M., Tibbetts, Y., Canning, E., & Hyde, J. S. (2014). Harnessing values to promote motivation in education. In S. A. Karabenick & T. C. Urdan (Eds.), *Advances in motivation and achievement: Vol. 18. Motivational interventions* (pp. 71–107). Bingley, UK: Emerald. doi:10.1108/s0749-742320140000018002

Häussler, P., & Hoffmann, L. (2002). An intervention study to enhance girls' interest, self-concept, and achievement in physics classes. *Journal of Research in Science Teaching, 39*, 870–888. doi:10.1002/tea.10048

Hidi, S., & Ainley, M. (2008). Interest and self-regulation: Relationships between two variables that influence learning. In D. H. Schunk & B. J. Zimmerman (Eds.), *Motivation and self-regulated learning: Theory, research, and application* (pp. 77–109). Mahwah, NJ: Erlbaum.

Hidi, S., & Baird, W. (1986). Interestingness—A neglected variable in discourse processing. *Cognitive Science, 10*, 179–194. doi:10.1207/s15516709cog1002_3

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*, 111–127. doi:10.1207/s15326985ep4102_4

Hoffmann, L. (2002). Promoting girls' learning and achievement in physics classes for beginners. *Learning and Instruction, 12*, 447–465. doi:10.1016/S0959-4752(01)00010-X

Holland, J. L. (1985/1997). *Making vocational choices: A theory of vocational personalities and work environments*. Englewood Cliffs, NJ: Prentice Hall.

Hulleman, C. S., Durik, A. M., Schweigert, S. A., & Harackiewicz, J. M. (2008). Task values, achievement goals, and interest: An integrative analysis. *Journal of Educational Psychology, 100*, 398–416. doi:10.1037/0022-0663.100.2.398

Hulleman, C., & Harackiewicz, J. (2009). Promoting interest and performance in high school science classes. *Science, 326*, 1410–1412. doi:10.1126/science.1177067

Hulleman, C. S., Kosovich, J. J., Barron, K. E., & Daniel, D. B. (2016). Making connections: Replicating and extending the utility value intervention in the classroom. *Journal of Educational Psychology, 109*, 387–404. doi:10.1037/edu0000146

Jacobs, J. E., Davis-Kean, P., Bleeker, M. M., Eccles, J. S., & Malanchuk, O. (2005). "I can, but I don't want to": The impact of parents, interests, and activities on gender differences in math. In A. M. Gallagher & J. C. Kaufman (Eds.), *Gender differences in mathematics: An integrative psychological approach* (pp. 246–263). New York, NY: Cambridge University Press. doi:10.1017/CBO9780511614446.013

Jacobs, J. E., & Eccles, J. S. (2000). Parents, task values, and real-life achievement-related choices. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic and extrinsic motivation: The search for optimal motivation and performance* (pp. 405–439). San Diego, CA: Academic Press.

Jacobs, J., Lanza, S., Osgood, D. W., Eccles, J. S., & Wigfield, A. (2002). Ontogeny of children's self-beliefs: Gender and domain differences across grades one through 12. *Child Development, 73*, 509–527. doi:10.1111/1467-8624.00421

Katz, I., Assor, A., Kanat-Maymon, Y., & Bereby-Meyer, Y. (2006). Interest as a motivational resource: Feedback and gender matter, but interest makes the difference. *Social Psychology of Education, 9*, 27–42. doi:10.1007/s11218-005-2863-7

Keller, H. (with A. Sullivan & J. A. Macy). (1903). *The story of my life*. New York, NY: Doubleday, Page.

Kim, S., Lee, M. J., & Bong, M. (2009, April). *fMRI study on the effects of task interest and perceived competence during negative feedback processing*. Paper presented at the Meetings of the American Educational Research Association, San Diego, CA.

Krapp, A. (2002). An educational–psychological theory of interest and its relation to SDT. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 405–427). New York, NY: University of Rochester Press.

Krapp, A. (2003). Interest and human development: An educational–psychological perspective. *British Journal of Educational Psychology Monograph Series II, Development and Motivation: Joint Perspectives*, 57–84.

Krapp, A. (2005). Basic needs and the development of interest and intrinsic motivational orientations. *Learning and Instruction, 12*, 383–409. doi:10.1016/j.learninstruc.2005.07.007

Krapp, A. (2007). An educational–psychological conceptualization of interest. *International Journal of Educational and Vocational Guidance, 7*, 5–21. doi:10.1007/s10775-007-9113-9

Krapp, A., & Lewalter, D. (2001). Development of interests and interest-based motivational orientations: A longitudinal study in vocational school and work settings. In S. Volet & S. Järvela (Eds.), *Motivation in learning contexts: Theoretical advances and methodological implications* (pp. 209–232). New York, NY: Elsevier.

Kunter, M., Baumert, J., & Köller, O. (2007). Effective classroom management and the development of subject-related interest. *Learning and Instruction, 17*, 494–509. doi:10.1016/j.learninstruc.2007.09.002

Lawless, K. A., & Kulikowich, J. M. (2006). Domain knowledge and individual interest: The effects of academic level and specialization in statistics and psychology. *Contemporary Educational Psychology, 31*, 30–43. doi:10.1016/j.cedpsych.2005.01.002

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior, 45*, 79–122. doi:10.1006/jvbe.1994.1027

Lent, R. W., Brown, S. D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology, 47*, 36–49. doi:10.1037/0022-0167.47.1.36

Linnenbrink-Garcia, L., Durik, A. M., Conley, A. M., Barron, K. E., Tauer, J. M., Karabenick, S. A., & Harackiewicz, J. M. (2010). Measuring situational interest in academic domains. *Educational and Psychological Measurement, 70*, 647–671. doi:10.1177/0013164409355699

Lipstein, R., & Renninger, K. A. (2007). "Putting things into words": 12–15-year-old students' interest for writing. In P. Boscolo & S. Hidi (Eds.), *Motivation and writing: Research and school practice* (pp. 113–140). New York, NY: Kluwer Academic/Plenum Press.

Magner, U. I. E., Schwonke, R., Aleven, V., Popescu, O., & Renkl, A. (2014). Triggering situational interest by decorative illustrations both fosters and hinders learning in computer-based learning environments. *Learning and Instruction, 29*, 141e 152. doi:10.1016/j.learninstruc.2012.07.002

Marsh, H. W. (1987). The big-fish-little-pond effect on academic self-concept. *American Psychologist, 79*, 280–295. doi:10.1016/j.lindif.2015.07.009

Marsh, H. W., Trautwein, U., Lüdtke, O., Köller, O., & Baumert, J. (2005), Academic self-concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Development, 76*, 397–416. doi:10.1111/j.1467–8624.2005.00853

Mayer, R. E. (2005). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 31–48). New York, NY: Cambridge University Press.

Mayer, R. E., Griffith, E., Jurkowitz, I. T. N., & Rothman, D. (2008). Increased interestingness of extraneous details in a multimedia science presentation leads to decreased learning. *Journal of Experimental Psychology: Applied, 14*, 329–339. doi:10.1037/a0013835

Meyer, D. K., & Turner, J. C. (2002). Discovering emotion in classroom motivation research. *Educational Psychologist, 37*, 107–114. doi:10.1207/S15326985EP3702_5

Michaelis, J. E., & Nathan, M. J. (2015). *The four-phase interest development in engineering survey*. Presented at the conference of the American Society of Engineering Education (ASEE 2015), Educational Research Methods (ERM) Division, Seattle, WA. doi:10.18260/p.25117

Mitchell, M. (1993). Situational interest: Its multifaceted structure in the secondary school mathematics classroom. *Journal of Educational Psychology, 85*, 424–436. doi:10.1037/0022-0663.85.3.424

Moeller, J., Dietrich, J., Eccles, J. S., & Schneider, B. (2017). On the variability and long-term stability of passion: A longitudinal experience sampling approach. *Journal for Research on Adolescence, 27*, 344–361. doi:10.1111/jora.12297

Nolen, S. B. (2007). Young children's motivation to read and write: Development in social contexts. *Cognition and Instruction, 25*, 219–270. doi:10.1080/07370000701301174

Palmer, D. H. (2004). Situational interest and the attitudes towards science of primary teacher education students. *International Journal of Science Education, 26*, 895–908. doi:10.1080/0950069032000177262

Palmer, D. H. (2009). Student interest generated during an inquiry skills lesson. *Journal of Research in Science Teaching, 46*, 147–165. doi:10.1002/tea.20263

Palmer, D. A., Dixon, J., & Archer, J. (2016). Identifying underlying causes of situational interest in a science course for preservice elementary teachers. *Science Education, 100*, 1039–1061. doi:10.1002/sce.21244

Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotion.* New York, NY: Oxford University Press.

Pasupathi, M., & Rich, B. (2005). Inattentive listening undermines self-verification in personal storytelling. *Journal of Personality, 73*, 1051–1085. doi:10.1111/j.1467-6494.2005.00338.x

Pekrun, R. (2000). A social–cognitive, control-value theory of achievement emotions. In J. Heckhausen (Ed.), *Motivational psychology of human development* (pp. 143–163). Oxford, UK: Elsevier. doi:10.1016/S0166-4115(00)80010-2

Pressick-Kilborn, K., & Walker, R. (2002). The social construction of interest in a learning community. In D. M. McInerney & S. van Etten (Eds.), *Research on sociocultural influences on motivation and learning: An historical perspective* (Vol. 2, pp. 153–182). Greenwich, CT: Information Age.

Pugh, K. J. (2002). Teaching for idea-based, transformative experiences in science: An investigation of the effectiveness of two instructional elements. *Teachers College Record, 104*, 1101–1137.

Pugh, K. J. (2004). Newton's laws beyond the classroom walls. *Science Education, 88*, 182–196. doi:10.1002/sce.10109

Pugh, K. J., Linnenbrink-Garcia, L., Koskey, K. L., Stewart, V. C., & Manzey, C. (2010). Motivation, learning, and transformative experience: A study of deep engagement in science. *Science Education, 94*, 1–28. doi:10.1002/sce.20344

Pugh, K., Linnenbrink-Garcia, L., Phillips, M. M., & Perez, T. (2015). Supporting the development of transformative experience and interest. In K. A. Renninger, M. Nieswandt, & S. Hidi (Eds.), *Interest in mathematics and science learning* (pp. 385–396). Washington, DC: American Educational Research Association.

Renninger, K. A. (1990). Children's play interests, representation, and activity. In R. Fivush & J. Hudson (Eds.), *Emory cognition series: Vol. III. Knowing and remembering in young children* (pp. 127–165). New York, NY: Cambridge University Press.

Renninger, K. A. (2000). Individual interest and its implications for understanding intrinsic motivation. In C. Sansone & J. M. Harackiewicz (Eds.), *Intrinsic motivation: Controversies and new directions* (pp. 373–404). San Diego, CA: Academic Press. doi:10.1016/B978-012619070-0/50035-0

Renninger, K. A. (2009). Interest and identity development in instruction: An inductive model. *Educational Psychologist, 44*(2), 1–14. doi:10.1080/00461520902832392

Renninger, K. A. (2010). Working with and cultivating interest, self-efficacy, and self-regulation. In D. Preiss & R. Sternberg (Eds.), *Innovations in educational psychology: Perspectives on learning, teaching and human development* (pp. 107–138). New York, NY: Springer.

Renninger, K. A., Austin, L., Bachrach, J. E., Chau, A., Emmerson, M. S., King, R. B.,...Stevens, S. J. (2014). Going beyond Whoa! That's cool! Achieving science interest and learning with the ICAN Intervention. In S. Karabenick & T. Urdan (Eds.), *Motivation-based learning interventions, Advances in Motivation and Achievement Series* (Vol. 18, pp. 107–140). Bingley, UK: Emerald. doi:10.1108/S0749-742320140000018003

Renninger, K. A., Cai, M., Lewis, M., Adams, M., & Ernst, K. (2011). Motivation and learning in an online, unmoderated, mathematics workshop for teachers. R. Small (Ed.), *Educational technology, research and development* [Special issue: Motivation and New Media], *59*, 229–247. doi:10.1007/s11423-011-9195-4

Renninger, K. A., Ewen, E., & Lasher, A. K. (2002). Individual interest as context in expository text and mathematical word problems. *Learning and Instruction, 12*, 467–491. doi:10.1016/S0959-4752(01)00012-3

Renninger, K. A., & Hidi, S. (2011). Revisiting the conceptualization, measurement, and generation of interest. *Educational Psychologist, 46*, 168–184. doi:10.1080/00461520.2011.587723

Renninger, K. A., & Hidi, S. (2016). *The power of interest for motivation and engagement.* New York, NY: Routledge.

Renninger, K. A., & Hidi, S. E. (2019). Interest development and learning. In K. A. Renninger & S. E. Hidi (Eds.), *The Cambridge handbook of motivation and learning* (pp. 265–296). Cambridge, UK: Cambridge University Press.

Renninger, K. A., Kensey, C. C., Stevens, S. J., & Lehman, D. L. (2015). Perceptions of science and their role in the development of interest. In K. A. Renninger, M. Nieswandt, & S. E. Hidi (Eds.), *Interest in mathematics and science learning* (pp. 93–110), Washington, DC: American Educational Research Association.

Renninger, K. A., & Lipstein, R. (2006). Come si sviluppa l'interesse per la scrittura; Cosa volgliono gli studenti e di cosa hannobisogno? [Developing interest for writing: What do students want and what do students need?] *Età Evolutiva, 84*, 65–83. doi:10.2307/30047170

Renninger, K. A., Ren, Y., & Kern, H. M. (2018). Motivation, engagement, and interest: "In the end, it came down to you and how you think of the problem." In F. Fischer, C. E. Hmelo-Silver, S. R. Goldman, & P. Reimann (Eds.), *International handbook of the learning sciences.* New York, NY: Routledge.

Renninger, K. A., & Riley, K. (2013). Interest, cognition, and the case of L– and science. In S. Kreitler (Ed.). *Cognition and motivation: Forging an interdisciplinary perspective* (pp. 352–382). New York, NY: Cambridge University Press.

Renninger, K. A., Sansone, C., & Smith, J. L. (2004). Love of learning. In C. Peterson & M. E. P. Seligman (Eds.), *Character strengths and virtues: A handbook and classification* (pp. 161–179). New York, NY: Oxford University Press.

Renninger, K. A., & Schofield, L. S. (2014, April). Assessing STEM interest as a developmental motivational variable. Poster presented as part of a structured poster session (K. A. Renninger & S. Hidi, Chairs), *Current approaches to interest measurement.* American Educational Research Association, Philadelphia, PA.

Renninger, K. A., & Wozniak, R. (1985). Effect of interest on attentional shift, recognition, and recall in young children. *Developmental Psychology, 21*, 624–632. doi:10.1037/0012-1649.21.4.624

Rotgans, J. I., & Schmidt, H. G. (2011). Situational interest and academic achievement in the active-learning classroom. *Learning and Instruction, 21*, 58–67. doi:10.1016/j.learninstruc.2009.11.001

Rounds, J., & Su, R. (2014). The nature and power of interests. *Current Directions in Psychological Science, 23*, 98–103. doi:10.1177/0963721414522812

Sansone, C., Geerling, D. M., Thoman, D. B., & Smith, J. L. (2019). Self-regulation of motivation for learning: A renewable resource. In K. A. Renninger & S. E. Hidi (Eds.), *The Cambridge handbook of motivation and learning* (pp. 87–110). Cambridge, UK: Cambridge University Press.

Sansone, C., & Thoman, D. B. (2005a). Does how we feel affect what we learn? Some answers and new questions. *Learning and Instruction, 15*, 507–515. doi:10.1016/j.learninstruc.2005.07.015

Sansone, C., & Thoman, D. B. (2005b). Interest as the missing motivator in self-regulation. *European Psychologist, 10,* 175–186. doi:10.1027/1016-9040.10.3.175

Sansone, C., Thoman, D., & Fraughton, T. (2015). The relation between interest and self-regulation in mathematics and science. In K. A. Renninger, M. Nieswandt, & S. Hidi (Eds.), *Interest in mathematics and science learning* (pp. 111–131). Washington, DC: American Educational Research Association.

Sansone, C., Weir, C., Harpster, L., & Morgan, C. (1992). Once a boring task always a boring task? Interest as a self-regulatory mechanism. *Journal of Personality and Social Psychology, 63,* 379–390.

Sansone, C., Wiebe, D. J., & Morgan, C. (1999). Self-regulating interest: The moderating role of hardiness and conscientiousness. *Journal of Personality, 67,* 701–733. doi:10.1111/1467-6494.00070

Schiefele, U. (2009). Situational and individual interest. In K. Wentzel & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 197–222). New York, NY: Routledge.

Schiefele, U., & Csikszentmihalyi, M. (1994). Interest and the quality of experience in classrooms. *European Journal of Psychology of Education, 9,* 251–270.

Schiefele, U., & Csikszentmihalyi, M. (1995). Motivation and ability factors in mathematics experience and achievement. *Journal of Research in Mathematics Education, 26,* 163–181. doi:10.2307/749208

Schiefele, U., Krapp, A., Wild, K-P., & Winteler, A. (1993). Eine neue Version des Fragebogens zum Studieninteresse (FSI). Untersuchungen zur Reliabilität und Validität [A new version of the Study Interest Questionnaire (SIQ)]. *Diagnostica, 39,* 335–351.

Schraw, G., Bruning, R., & Svoboda, C. (1995). Sources of situational interest. *Journal of Reading Behavior, 27,* 1–17. doi:10.1080/10862969509547866

Silvia, P. J. (2006). *Exploring the psychology of interest.* New York, NY: Oxford University Press.

Thoman, D. B., Sansone, C., & Pasupathi, M. (2007). Talking about interest: Exploring the role of social interaction for regulating motivation and the interest experience. *Journal of Happiness Studies, 8,* 335–370. doi:10.1007/s10902-006-9016-3

Trautwein, U., Lüdtke, O., Nagy, N., Lenski, A., Niggli, A., & Schnyder, I. (2015). Using individual interest and conscientiousness to predict academic effort: Additive, synergistic, or compensatory effects? *Journal of Personality and Social Psychology, 109,* 142–162.

Tsai, Y. M., Kunter, M., Lüdtke, O., Trautwein, U., & Ryan, R. M. (2008). What makes lessons interesting? The role of situational and individual factors in three school subjects. *Journal of Educational Psychology, 100,* 460–472. doi:10.1037/0022-0663.100.2.460

Turner, S. A., Jr., & Silvia, P. J. (2006). Must things be pleasant? A test of competing appraisal structures. *Emotion, 6,* 670–674. doi:10.1037/1528-3542.6.4.670

Walkington, C., & Bernacki, M. (2015). Students authoring personalized "algebra stories": Problem-posing in the context of out-of-school interests. *Journal of Mathematical Behavior, 40B,* 171–191. doi:10.1016/j.jmathb.2015.08.001

Wang, Z., & Adesope, O. (2016). Exploring the effects of seductive details with the 4-phase model of interest. *Learning and Motivation, 55,* 65–77. doi:10.1016/j.lmot.2016.06.003

Watt, H. M. G. (2004). Development of adolescents' self-perceptions, values, and task perceptions according to gender and domain in 7th- through 11th-grade Australian students. *Child Development, 75,* 1556–1574. doi:10.1111/j.1467-8624.2004.00757.x

Wigfield, A., & Cambria, J. (2010). Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review, 30,* 1–35. doi:10.1016/j.dr.2009.12.001

Wigfield, A., Eccles, J., Schiefele, U., Roeser, R., & Davis-Kean, P. (2006). Development of achievement motivation. In R. Lerner & W. Damon (Series Eds.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (6th ed., pp. 933–1002). New York, NY: Wiley.